

ELEMENT MATERIAL EXPOSURE EXPERIMENT BY EFFU

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SUMMARY

National Space Development Agency of JAPAN(NASDA) is planning to perform "Element Material Exposure Experiment" using Exposed Facility Flyer Unit(EFFU). Several materials which will be used on JEM(Japanese Experiment Module for the Space Station) will be exposed. Space environment monitoring is also planned in this experiment. Several ground based tests are now being performed and getting useful data.

INTRODUCTION

EFFU(Exposed Facility Flyer Unit) is a module of SFU(Space Flyer Unit) which is shown in Figure 1. SFU is promoted by three Japanese organizations: National Space Development Agency of Japan (NASDA) on behalf of the Science and Technology Agency (STA); the Institute of Space and Astronautical Science (ISAS) on behalf of the Ministry of Education, Culture and Science(MOE); and New Energy and Industrial Technology Development Organization(NEDO) on behalf of the Ministry of International Trade and Industry (MITI). SFU system parameters are the following:

Dimensions 4.7[m] dia., 2.5[m] height
Solar array paddle 24.4[m] length, 2.36[m] width
Weight 4.0[ton] at launch, 3.2[ton] at retrieval
Attitude Sun pointing
Control 3-axis stabilized
Microgravity 10-4[g] condition
Mission orbit 300 - 500[km]
Launch H-2 Rocket Test Flight#3
Retrieval NASA Space Shuttle

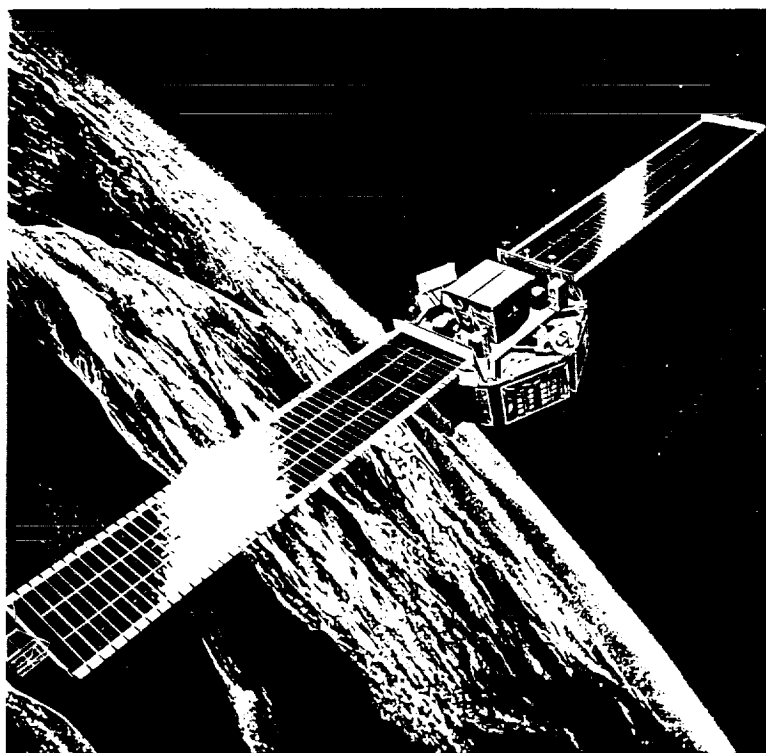


Figure 1: Space Flyer Unit (SFU)
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EFFU is developed to improve the reliability of the JEM exposed facility. The missions are the following:

1. Equipment Exchange Mechanism Test
2. Active Thermal Control System Test
3. Element Material Exposure Experiment
4. Physical Experiment by Gas Dynamics Experiment Facility

SFU will be launched in the beginning of 1995. The operational orbit is almost the same as the Space Station. The nominal exposed period of EFFU is about 6 months. Some element materials of JEM will be exposed as "ELEMENT MATERIAL EXPOSURE EXPERIMENT" which is one of the EFFU missions. The degradation of the materials is due to atomic oxygen (AO), ultra-violet rays (UV), and radiation, including high energy ions. The other materials will also be installed to monitor these environments quantitatively. Several ground based tests are now being performed in order to select the most suitable materials for monitoring and to get data for estimating each fluence after retrieval.

EXPERIMENT

EFFU configuration is shown in Figure 2. The materials for the exposure experiment and for the monitoring will be attached on the side of the radiator panel facing the sun and on the truss without facing the sun.

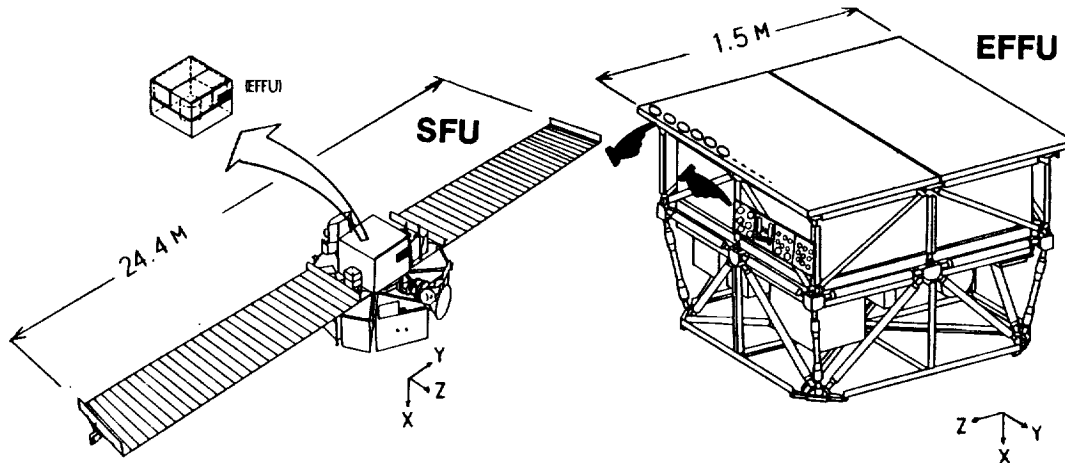


Figure 2: EFFU Configuration

Kawasaki Heavy Industries Co.,Ltd.;Nissan Motor Co.,Ltd;and Toshiba Co.,Ltd. are joining in the exposure experiment with NASDA and IHI. The purpose of the experiment is to investigate the degradation of material exposed for 6 months. The Materials for the exposure experiment are the following:

- (1)Solid Lubricant(HMB-34(MoS₂))
base:Aluminum Alloy,Stainless Steel,and Titanium Alloy
- (2)CFRP
- (3)Glass for Camera Lens
- (4)Thermal control materials
 - Anodized Aluminum
 - ITO coated Polyimide
 - SiO₂ coated Polyimide
 - Beta-Cloth
 - Flexible OSR
 - Silicone Paint
- (5)Electric Wire Covering
- (6)Glass for Solar Cell

The ground based tests are now being performed concerning AO,UV,and Electron Beam before the flight exposure experiment.

MONITORING

IHI is preparing some materials for the monitoring of space environments, atomic oxygen (AO), ultra-violet rays (UV), and radiation, including high energy ions that degrade an exposed material. The monitoring of AO and UV will be done passively; that is, each fluence will be estimated from the mass loss of material or optically changed material after retrieval, compared with ground based test data. CR-39 will be mounted for measuring LET distribution of high energy heavy ions.

Thermo luminescent dosimeter(TLD) and Alanine($\text{C}_3\text{H}_7\text{NO}_2$) dosimeter will be mounted for dose measurement.

AO MONITORING

The Polyimide film, KAPTON-HN, is a strong candidate for AO measuring material. The ground based tests were performed using two facilities in order to obtain the flight fluence evaluation data. IHI's AO test facility was used at first. AO is produced by the direct current arc dissociating method in the facility. The system diagram is shown in Figure 3. The merit of the facility is to be able to perform simulation tests in a short time. The $3.6\text{E}20$ [atoms/cm²] simulation test needs only an hour. The disadvantage is that produced AO has small translational energy about 0.2[eV]. The SEM photograph of KAPTON-100HN film specimen after AO irradiation is shown in Figure 4. The reaction efficiency R_e was $1.2\text{E}-24$ [cm³/atom] which is about a third of Space. Another test was performed at well-known PSI (Physical Science Inc.) to verify data obtained by IHI. The SEM photograph after irradiation is shown in Figure 5, which is Christmas tree-like and looks like the STS SEM photograph. The two test results are shown in Figure 6.

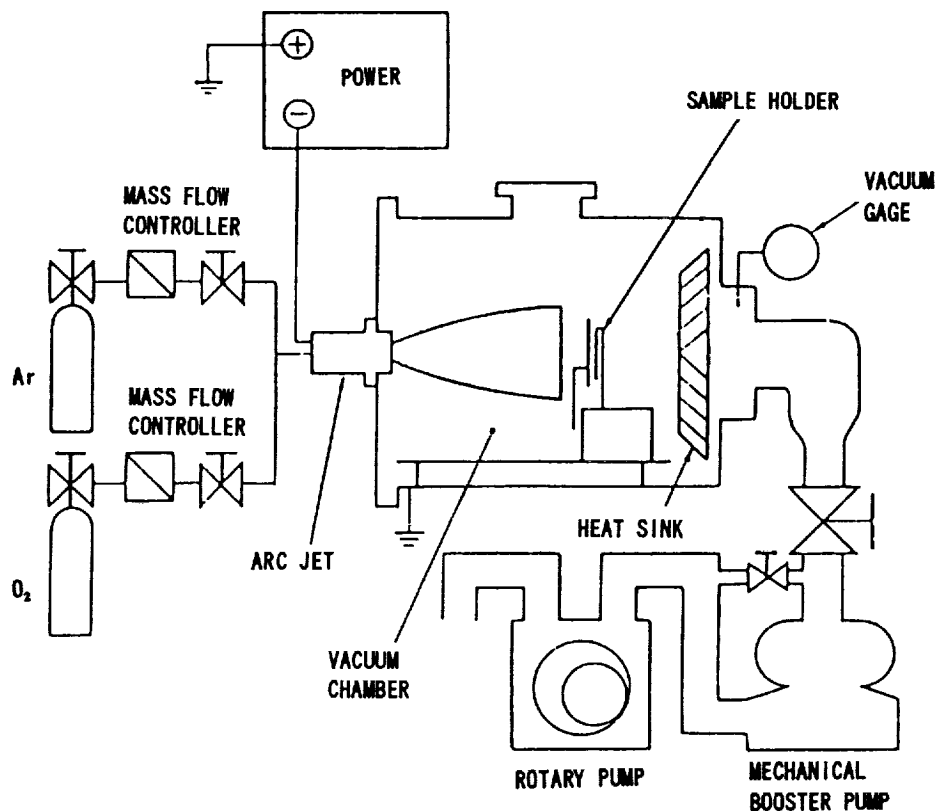
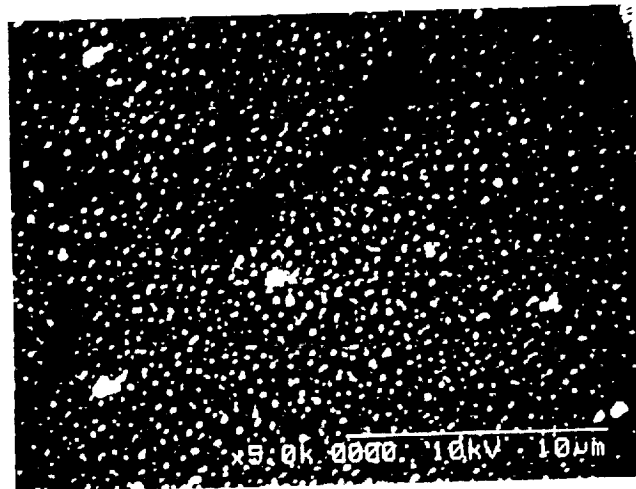
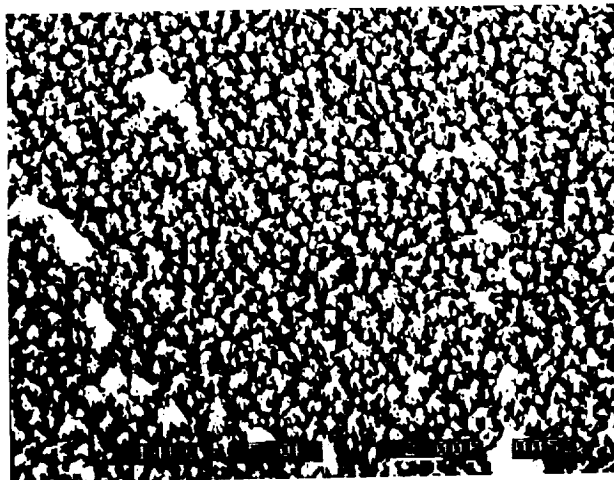


Figure 3: IHI Atomic Oxygen Irradiation Test Facility System Diagram



Irradiated AO 3.6×10^{20} [atoms/cm²]

**Figure 4: SEM Photograph Of KAPTON-100HN Film
(IHI AO Testing)**



4.51×10^{20} [atoms/cm²]

**Figure 5: SEM Photograph Of KAPTON-100HN Film
(PSI AO Testing)**

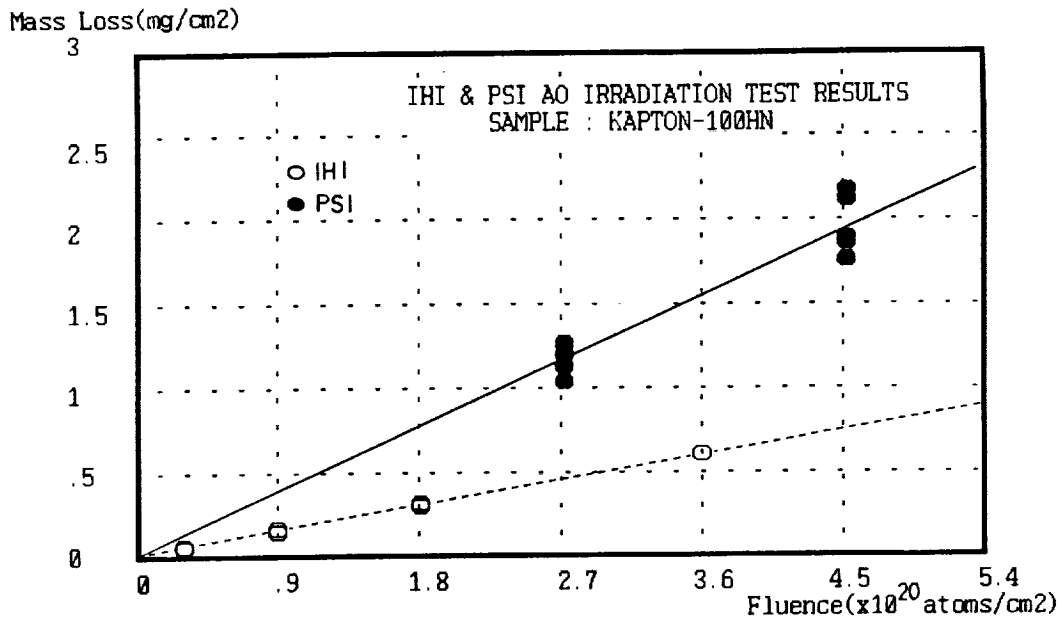
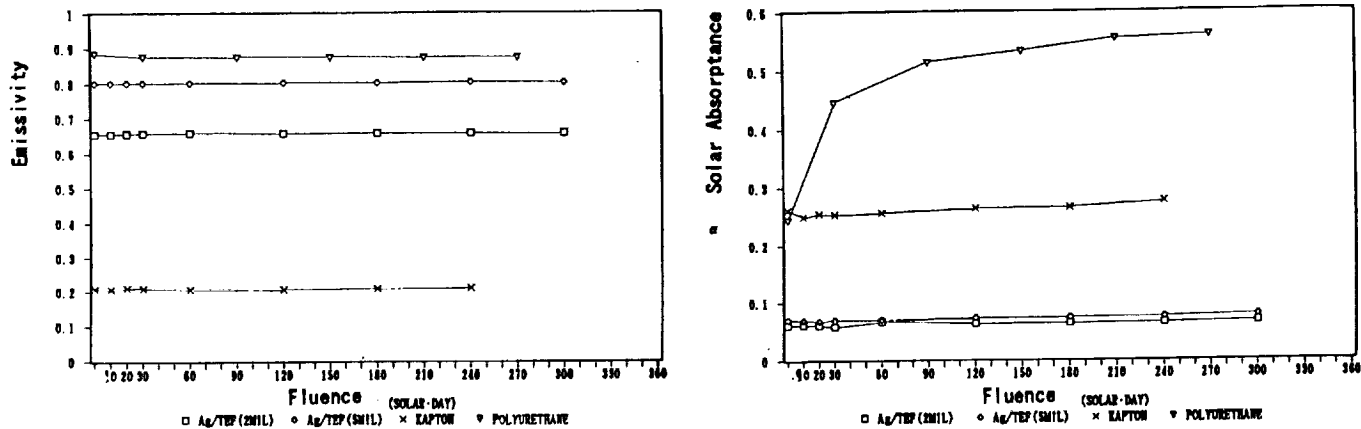


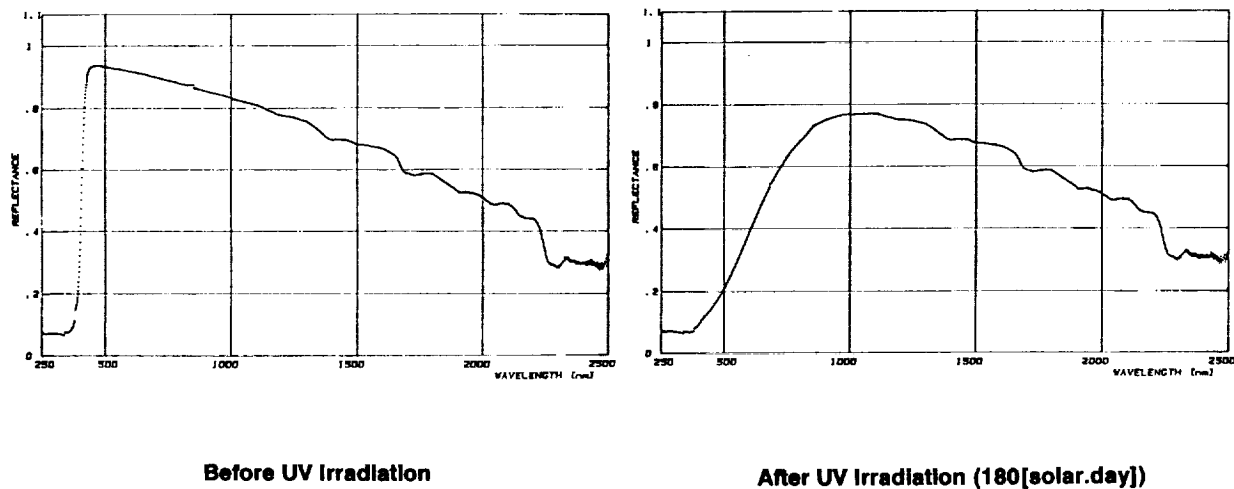
Figure 6: Atomic Oxygen Test Results
Mass Loss Versus AO Fluence

UV MONITORING

The UV fluence on orbit is planned to be estimated from optically changed material. The ground based tests to select the most suitable material for monitoring are under way. The four materials: Silvered Teflon (TEF) 2[MIL] and 5[MIL] thickness; KAPTON-100HN; and acrylic urethane based white paint made in Japan were tested at NASDA Tsukuba Space Center in 1993. The test results are shown in Figure 7. As shown in the figure, no change in emissivity of all materials was recognized, and obvious change was recognized in only solar absorptance of the white paint. The reflection spectrums of the paint are shown in Figure 8, but the change was almost saturated, irradiating about 300 equivalent solar days, so this white paint is not suitable for monitoring in orbit for more than 6 months. The other materials, urethane based white paint, silicon based white paint, which has a stronger bond than urethane based paint, and fluorine based white paint and so on are now being tested.



**Figure 7: Ultraviolet Ray Irradiation Test Results
Optical Property Versus UV Fluence**



**Figure 8: Ultraviolet Ray Irradiation Test Results
Reflection Spectrum Of Acrylic Urethane**

RADIATION MONITORING

The radiation dose measurement will be made using Thermo luminescent dosimeters(TLD) and alanine dosimeters which are well-known dosimeters. TLDs are MSO ($\text{Mg}_2\text{SiO}_4\text{:Tb}$) and packed with CR-39 in an airtight aluminum box. The alanine dosimeters will be located completely exposed.

HIGH ENERGY HEAVY IONS MONITORING

CR-39 will be mounted on EFFU for measuring LET distribution of high energy heavy ions. The ground based tests are under way in order to obtain the calibration data.

SYNERGIC EFFECTS

It is important for each monitoring material to avoid other environment. The UV monitor has a UV passing glass cover which is about 2[mm] thick to avoid AO attack. But AO and UV monitors can't avoid electrons. The total number of electrons irradiated on EFFU orbit is estimated as follows:

Energy[MeV]	Number[/m2]
0.04-0.1	1.363E16
0.1 - 1	2.368E16
1 -	6.730E13

The electron beam irradiation tests are under testing to evaluate synergic effect at Japan Atomic Energy Research Institute. The reflection spectrums of acrylic urethane based white paint are shown in Figure 9. There is no effect recognized in optical property of the paint. The other materials including KAPTON are under testing now.

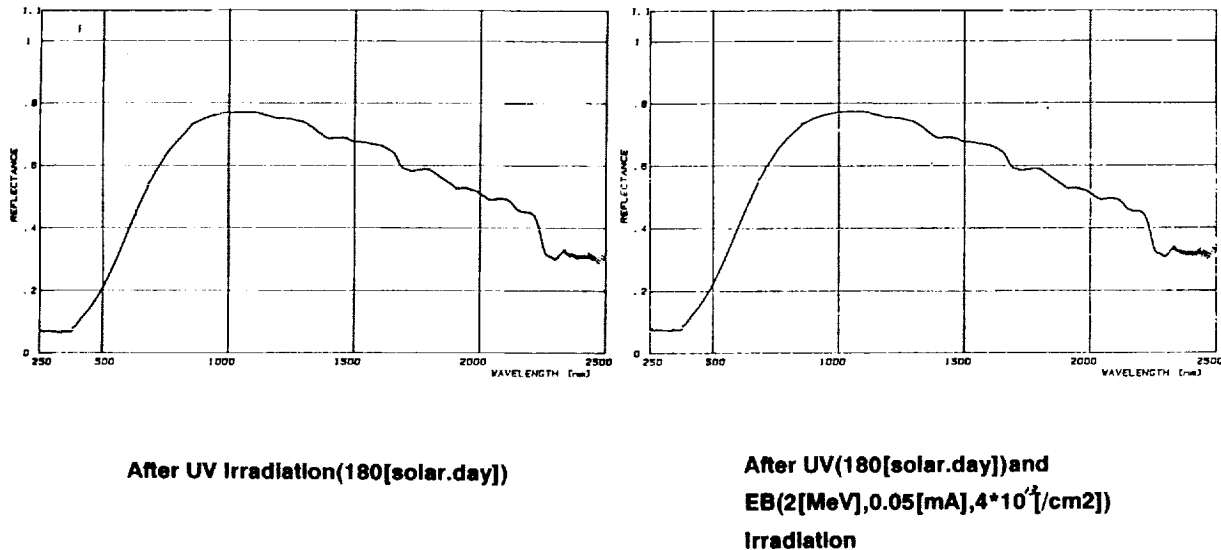


Figure 9: Synergic Effect Of Ultraviolet Ray And Electron Beam
Reflection Spectrum Of Acrylic Urethane

CONCLUSION

The material exposure experiment by EFFU is going to start in 1995. It is very important to obtain ground based test data before flight, especially for the monitor. The synergic effects are not ignored to evaluate material degradation and estimate AO and UV fluences accurately.

Lastly we greatly appreciate NASA Langley Research Center's precious advice.

REFERENCE

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2. L.J.Leger and J.T.Visentine "A Consideration of Atomic Oxygen Interactions with the Space Station", SPACECRAFT, Vol.23, No.5, Sept.-Oct., 1986

